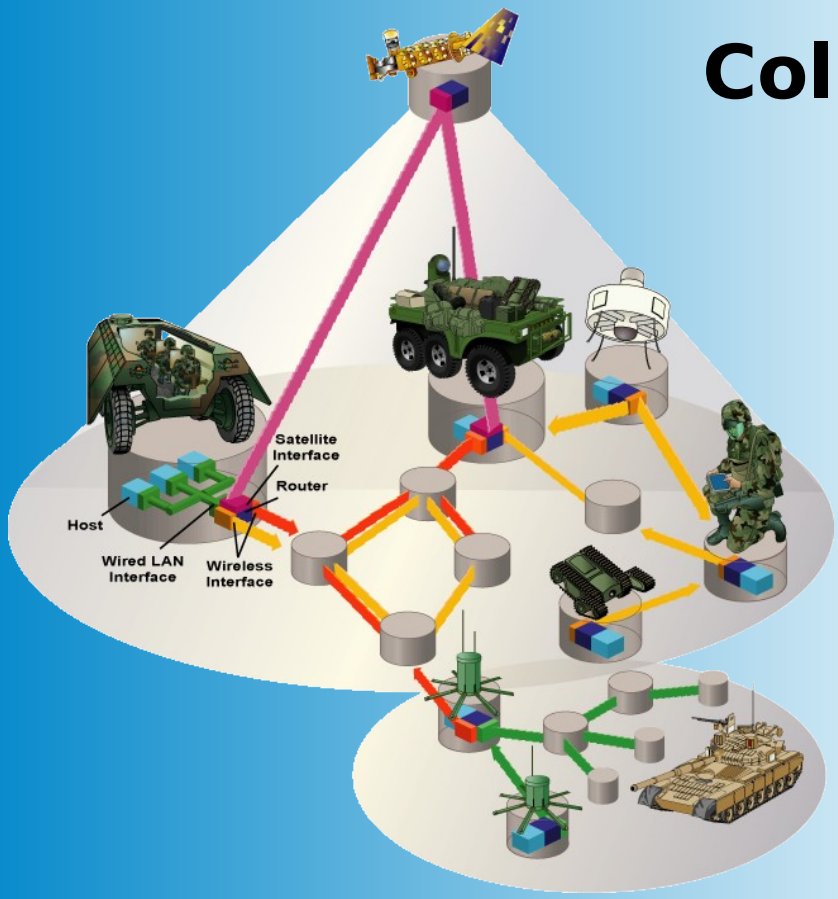
Collaborative Technology Alliance



Communications and Networks

Mr. Greg Cirincione
Collaborative Alliance Manager, ARL

Dr. Ken Young
Consortium Manager, Telcordia Technologies

Communications and Networks Collaborative Technology Alliance

Consortium Partners

- Telcordia Technologies (Lead)
- Network Associates
- BBN Technologies
- General Dynamics
- BAE SYSTEMS
- Georgia Tech
- U of Maryland
- U of Minnesota
- U of Delaware
- Princeton
- Johns Hopkins
- Morgan State

Objectives

Enable a fully-mobile, agile, situation-aware, and survivable lightweight force with internetted C⁴ISR systems.

Large, heterogeneous, wireless communication networks that:

- **Operate while on-the-move with a highly mobile network infrastructure**
- **Under severe bandwidth and energy constraints**
- **While providing secure, jam-resistant comms in**

Technical Areas

- **Survivable Wireless Mobile Networks**
- **Signal Processing for Comms-on-the-Move**
- **Secure Jam-Resistant Communications**
- **Tactical Information Protection**

Communication and Networks Collaborative Technology Alliance

PM: Telcordia Technologies, Dr. Ken Young

CAM: ARL, Mr. Greg Cirincione

Survivable Wireless Mobile Networks

Telcordia, Dr. Ken Young
ARL, Mr. Hal Harrelson

Highly Efficient & Robust Subnet Organization

BBN, Dr. J. Redi
UDel, Dr. E. Lloyd

Autonomous Internetworking

Telcordia, Dr. A. McAuley
JHU, Dr. I-J. Wang

Efficient, Reliable End-to-End Networking

Telcordia, Dr. M. Fecko
UDel, Dr. P. Amer

Network Management for MANETs

Telcordia, Dr. W. Chen
UDel, Dr. A. Sethi

Signal Processing for Comms-on-the-Move

Telcordia, Dr. Joe Liberti
ARL, Dr. Ananthram Swami

Multiple Access

UMinn, Dr. G. Giannakis

Multi-Input Multi-Output Systems

Telcordia, Dr. J. Liberti

Cross-Layer Designs and Novel Techniques

JHU, Dr. F. Davidson

Secure Jam-Resistant Communications

BAE, Dr. Diane Mills
ARL, Dr. Brian Sadler

Adaptive LPD Waveforms and Processing

Ga Tech, Dr. G. Stüber

Sensor Array Processing and Interference Rejection

UDel, Dr. G. Arce

Frequency-Hopping Systems

GD, Mr. J. Kleider

Tactical Information Protection

NAL, Mr. Dave Carman
ARL, Mr. Greg Cirincione

Highly Efficient Security Services and Infrastructure

NAL, Mr. D. Carman
UMd, Dr. J. Baras

Tactical Intrusion Detection

Telcordia, Mr. M. Little
Ga Tech, Dr. J. Cannady

Communication and Networks

Collaborative Technology Alliance

Survivable Wireless Mobile Networks

Networking:

- Support very mobile joint operations
- Automatic configuration for flexible deploymen

Signal Processing for Comms-on-the-Move

High Data Rate Communications:

- Hard for the enemy to detect or intercept
- Effective in noisy and hostile environment
- Enabling on-the-move operations

Secure Jam-Resistant Comms

Tactical Information Protection

Security:

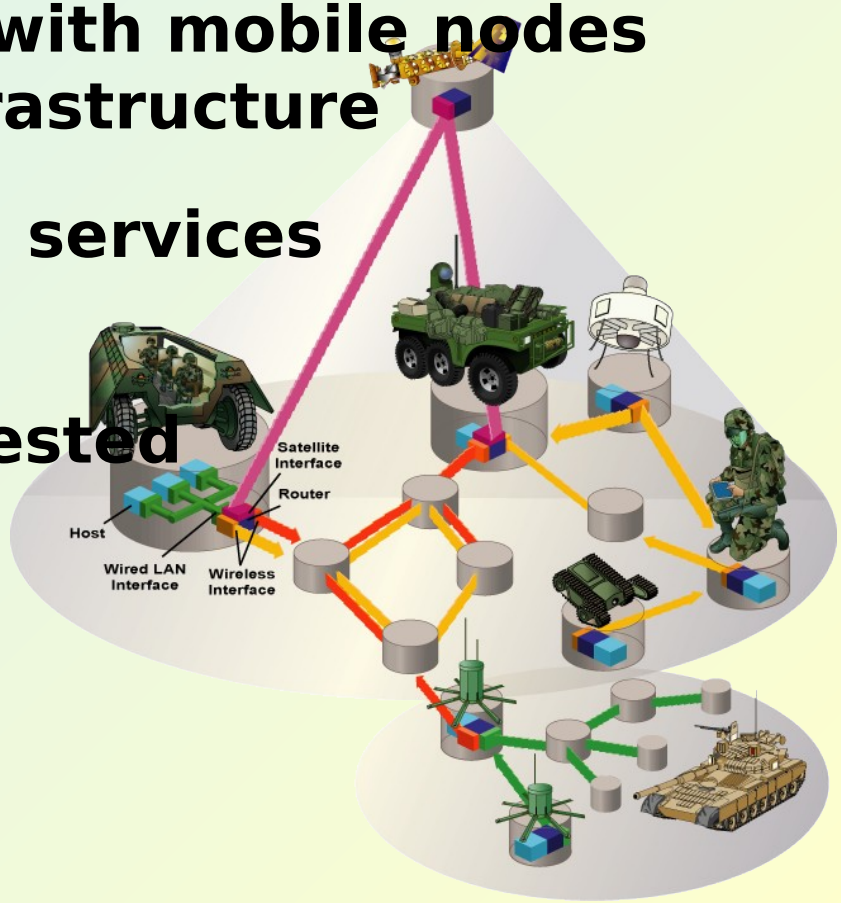
- Efficient information protection for mobile networks
- Without reliance on strategic services

Cross-layer designs: Improves adaptability and efficiency

- With no

Key Technical Challenges

- Limited energy, bandwidth, and processing resources
- Highly dynamic networks with mobile nodes AND mobile infrastructure
- Cannot rely on centralized services
- Communications channels are noisy and congested
- Difficult propagation environments
- Spectrum availability and coexistence
- Scalability to thousands of nodes



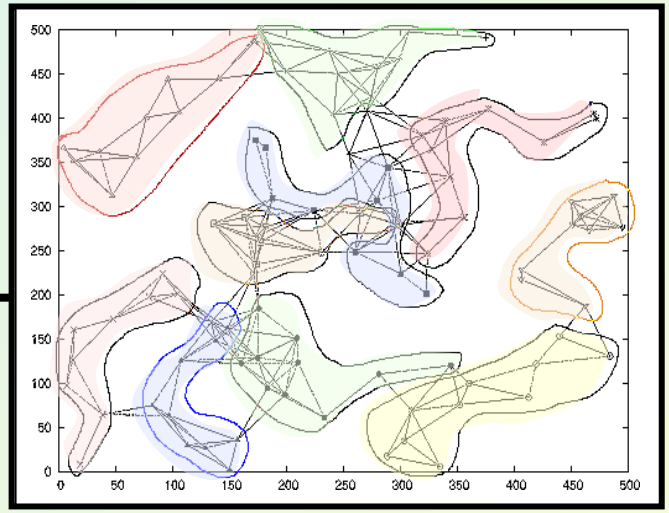
Vision

Enabling a network-centric Force that operates in a highly dynamic, wireless, mobile networking environment that is:

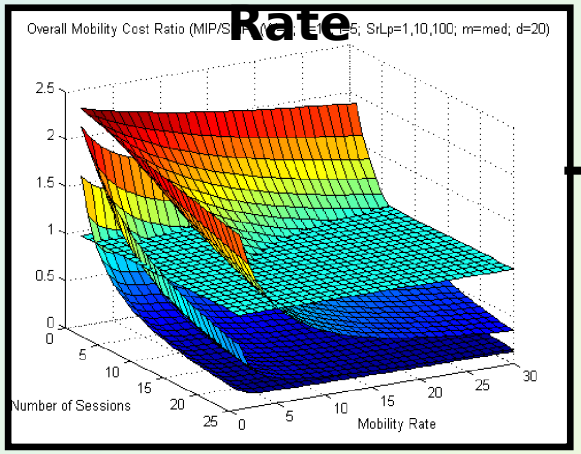
- **Rapidly deployable**
- **Self-organizing and self-configuring**
- **Self-contained**
- **Survivable and secure**
- **Interoperable with Joint Forces**

Survivable Wireless Mobile Networks Highlights

- Medium access control with directional antennas
- Domain autoconfiguration and dynamic clustering
- Energy-efficient network control



Mobility Cost vs. Sessions and Mobility Rate



- Dynamic and survivable network service pooling
- Mobility management
- Congestion control
- Fault localization

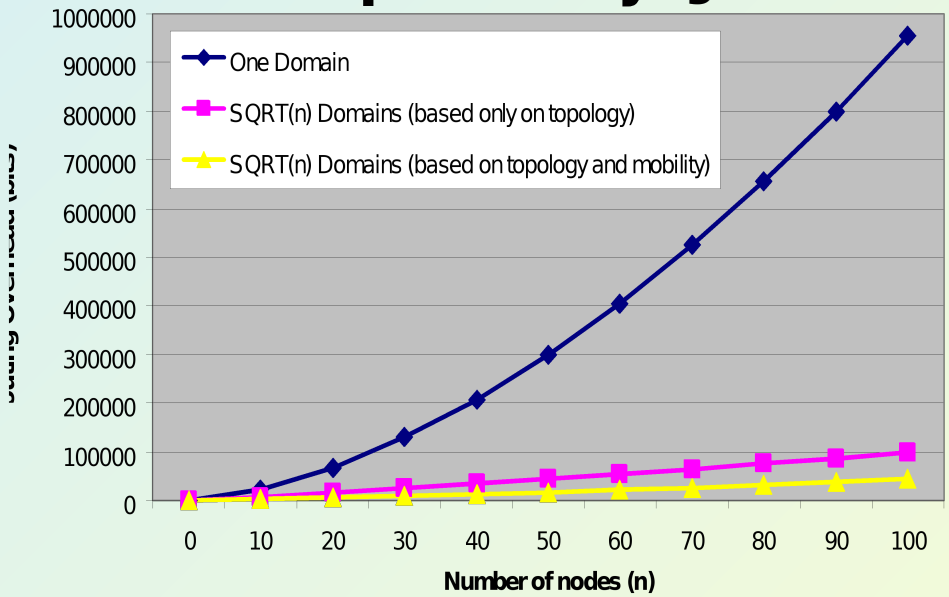
Autoconfiguring Domains for Mobile Networks

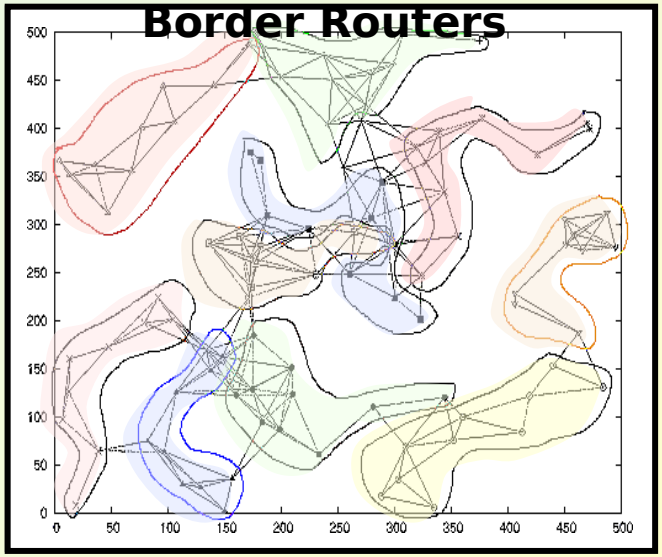
Benefits of Smart Domain Formation and Maintenance

- Large networks must be divided into domains for scalability
- Better manageability --- less personnel, more adaptability
- Better optimality and less overhead during mobility

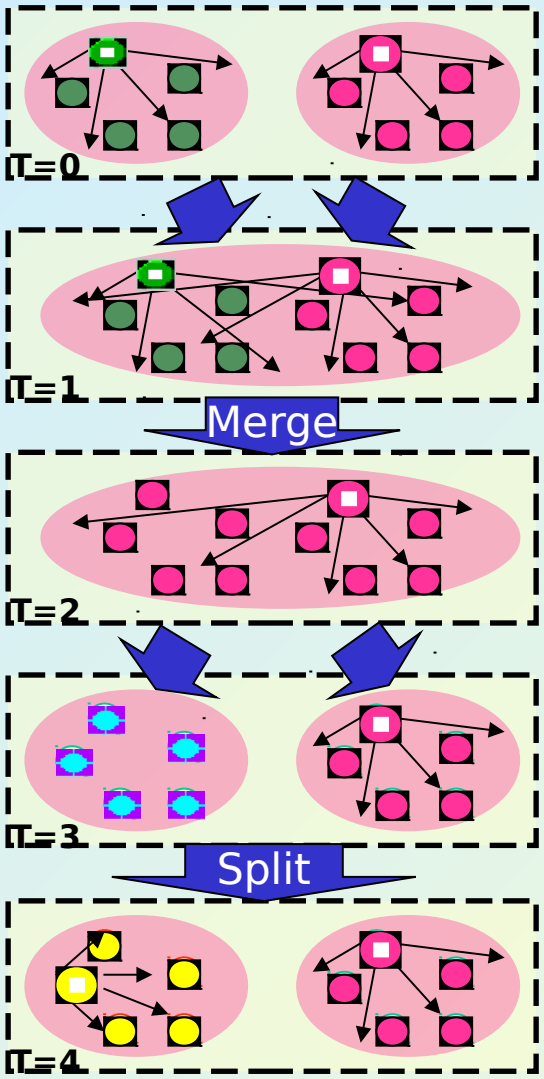
Routing Overhead

Domain Generation With Balanced Clustering and Mobility

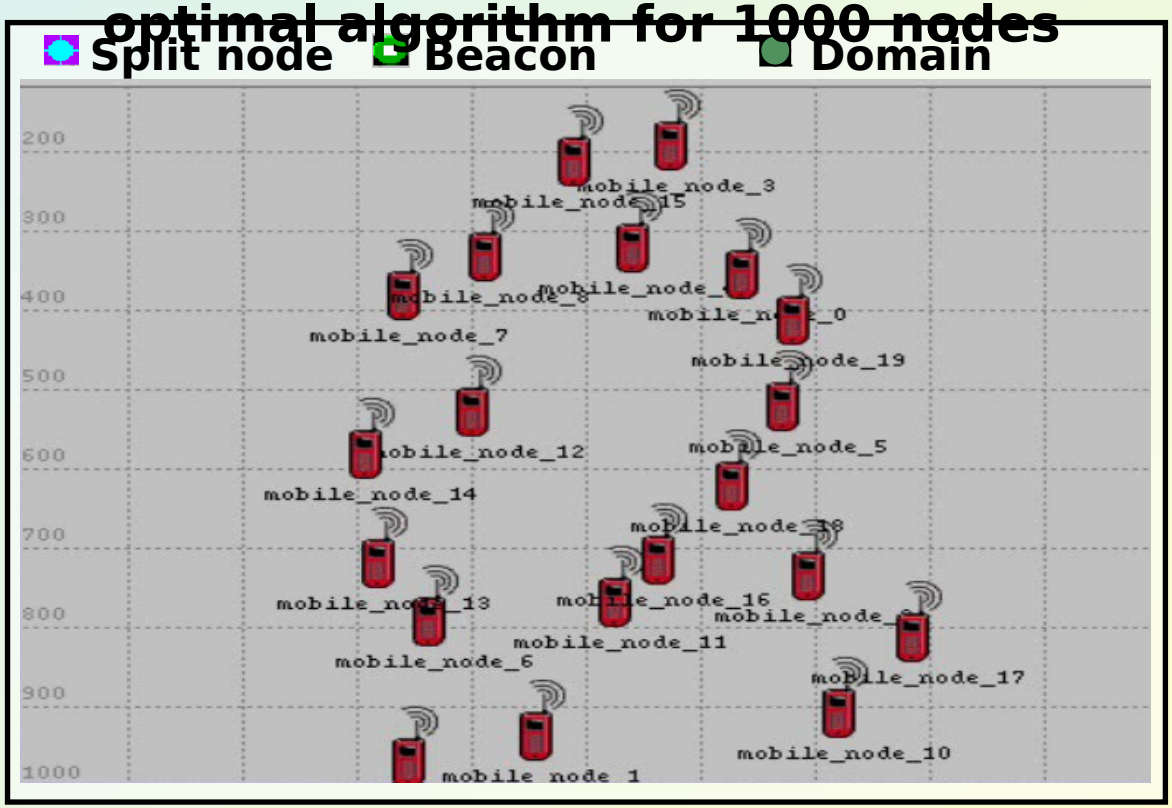




Dynamic Domain Maintenance



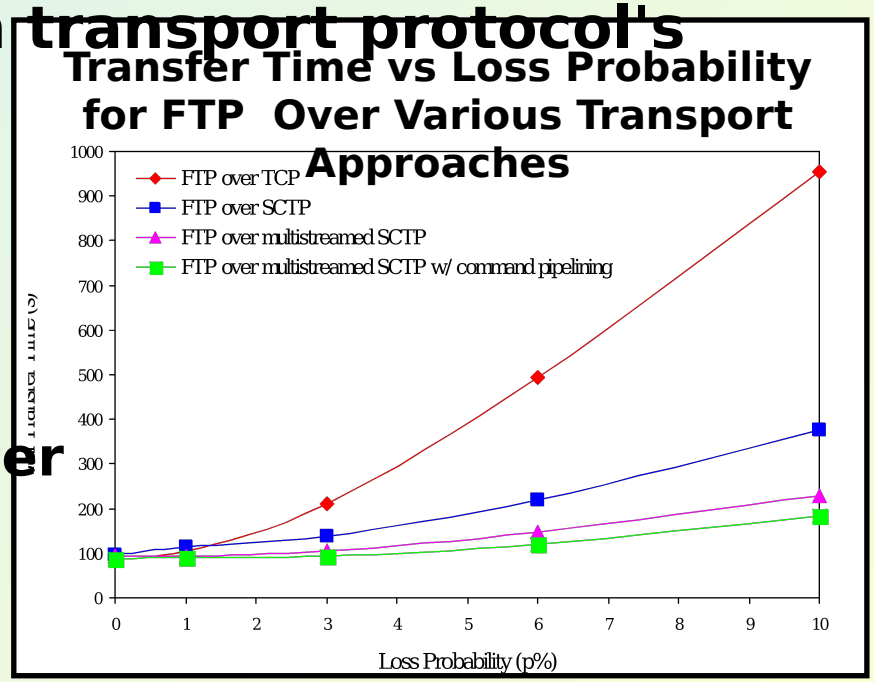
- Domains are maintained with a distributed simulated annealing algorithm
  - 1-2 orders of magnitude faster than optimal algorithm for 1000 nodes



Transitioned to the CERDEC MOSAIC ATD
Ongoing Transition to the Future Combat Systems --- LSI

Transport Layer Multistreaming for Faster File Transfers

- File transfers over standard Internet protocols have high latency and overhead over noisy wireless channels
- Exploiting next-generation transport protocol's multistreaming capability
  - Substantially reduces overhead
  - File transfers 2 - 5 times faster
  - While being more robust to losses
  - Without added complexity



SCTP = Stream Control Transmission Protocol

FTP = File Transfer Protocol

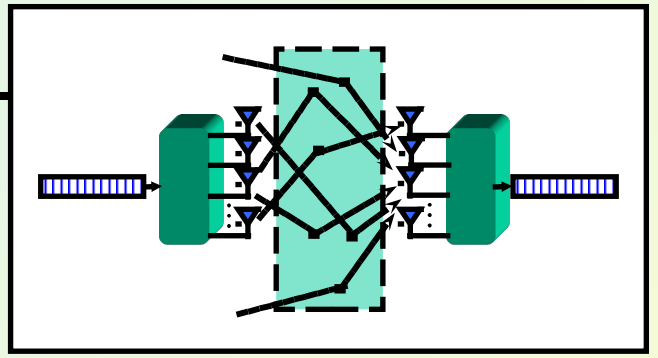
Transitioned to the CERDEC MOSAIC ATD

Internet Engineering Task Force Standardization and Simulation

Secure Communications Highlights

- Multiple access techniques
- Multi-Input Multi-Output (MIMO) systems for high data rates
- Ultra-wideband communications

MIMO System



Advanced Waveforms On Handheld JTRS Prototype

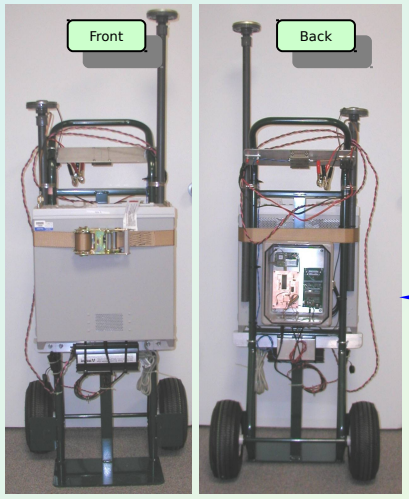
- Adaptive low power waveforms for covertness
- Multi-carrier modulation for anti-jam/spectral efficiency
- Array processing and

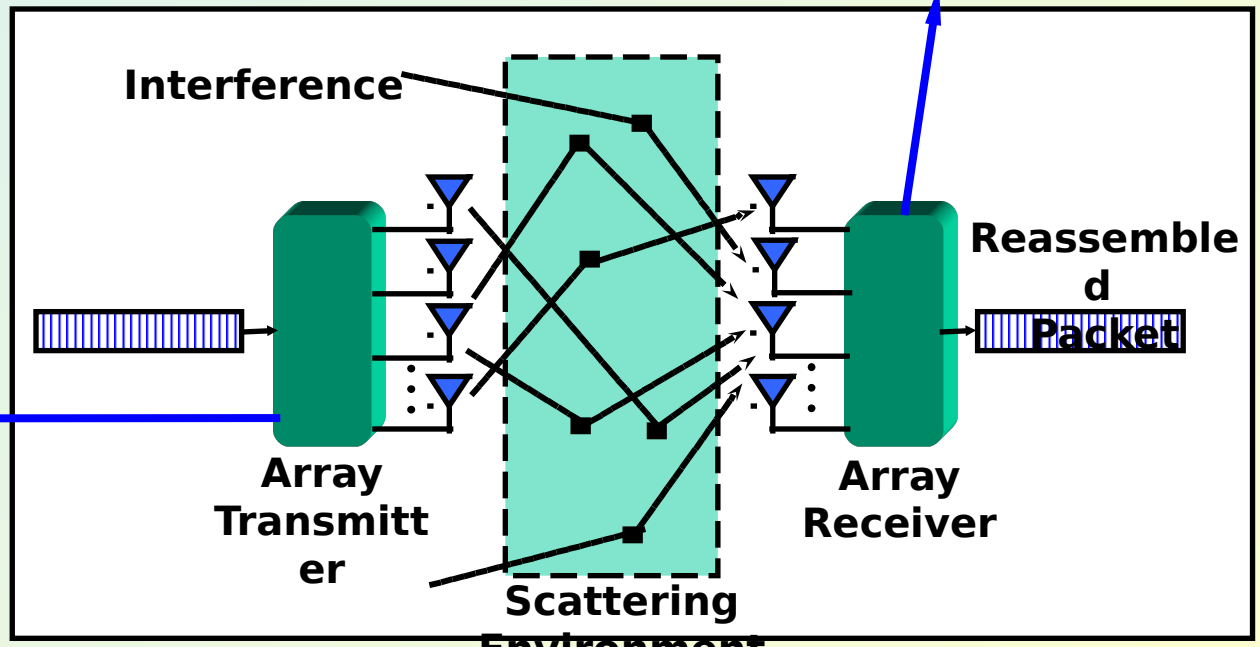
Multi-Input Multi-Output (MIMO) Experiments

- Experiments conducted on various MIMO waveforms and array processing algorithms
- Measurements taken on mobile MIMO testbed

Mobile MIMO Receiver in Van

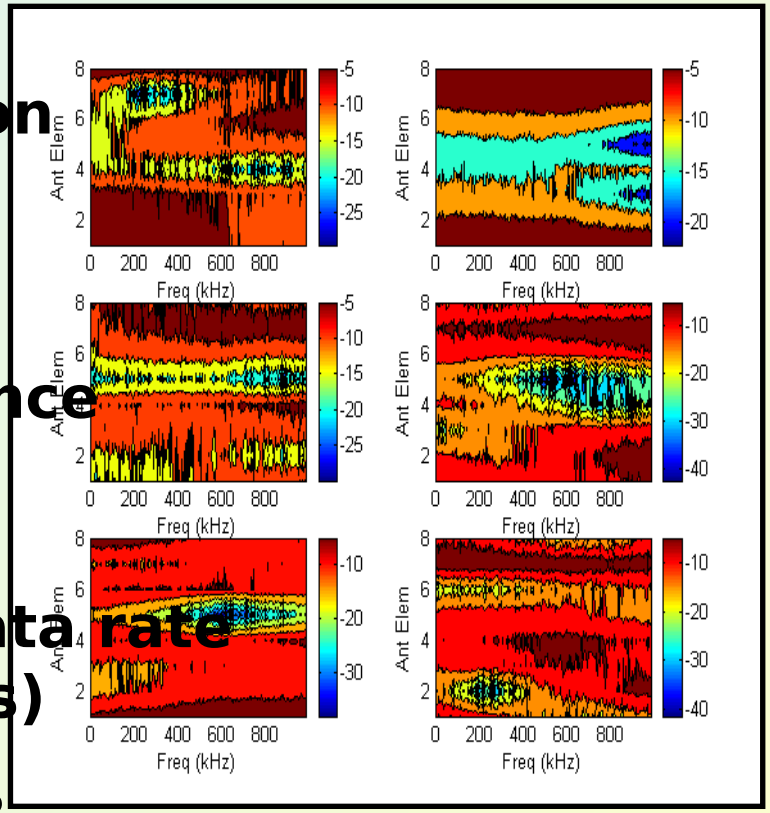
Time Synchronous Mobile MIMO Transmitter





High Data Rate Multi-Input Multi-Output (MIMO) System

- **MIMO systems make efficient use of available spectrum while on-the-move**
  - **Maximizes throughput**
  - **Reduces power consumption**
  - **Enables lighter, more powerful radios**
- **Demonstrated high performance Turbo-MIMO system**
  - **High spectral efficiency (10 bps/Hz) for high data rate comms (up to 40 Mbps)**
  - **In multi-user environments with high levels of noise**



Transitioned to CERDEC

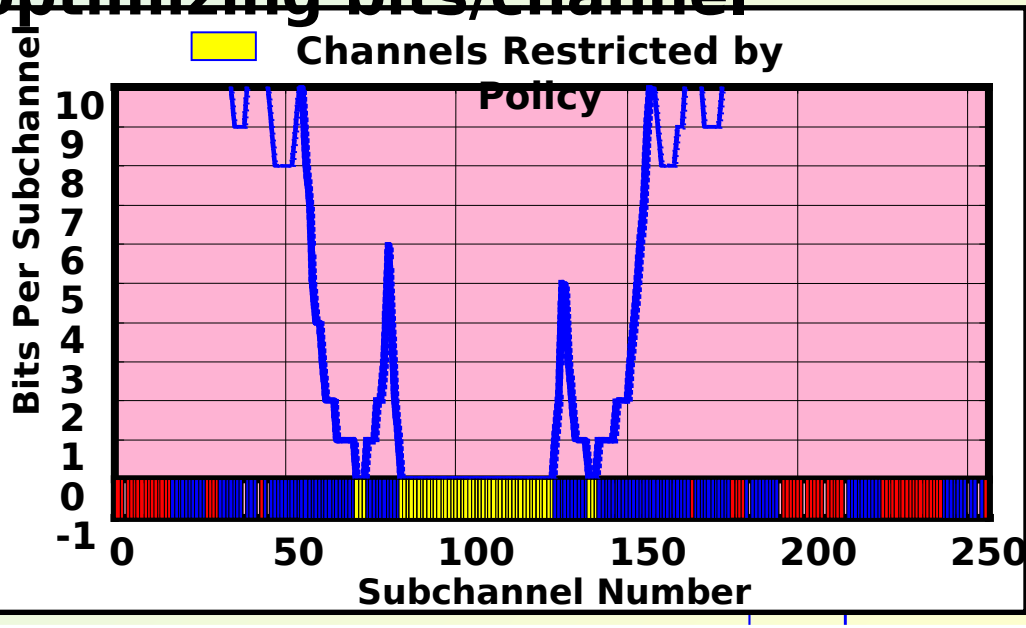
Adaptive Modulation to Reduce Effects of Interference

Interference Avoidance Algorithms

- Adaptively filter subchannels with jamming/interference
- Enforce spectral occupancy policies to avoid legacy or coalition waveforms
- Increases capacity by optimizing bits/channel

Before Signal

After Signal Avoidance



Ongoing transition to DARPA's Next Generation Comms (XG)

Integrated Synchronization and Watermarking Waveform

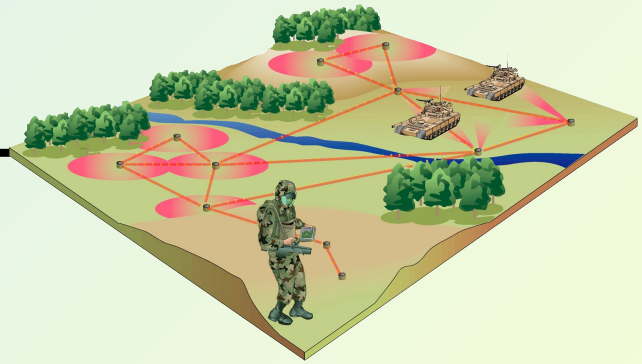
Radio-Frequency Watermarking

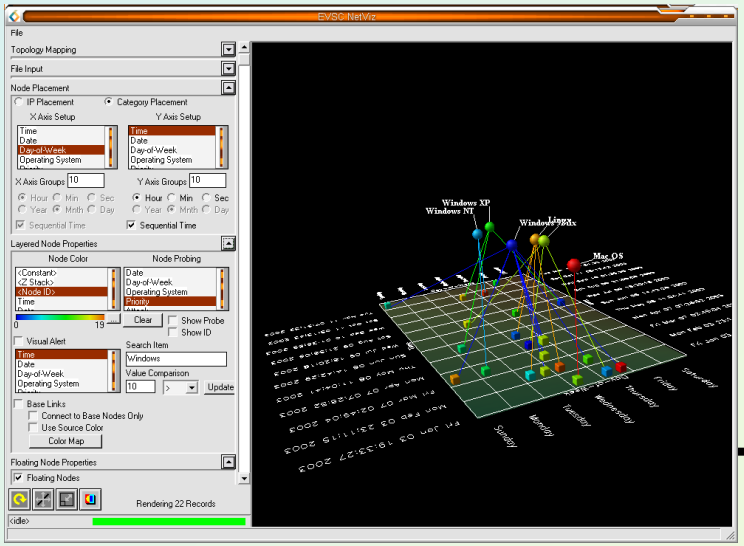
- Efficient physical layer authentication
- Integrated into multi-carrier anti-jam waveform
- Robust detection process with no bandwidth expansion
- Successfully implemented on handheld software-defined radio prototype
- Over-the-air testing validated watermark detection and image

Transitioned to Air Force Research Laboratory

Tactical Information Protection Highlights

- Distributed dynamic trust models and management
- Highly efficient group key management
- Survivable and secure distributed servers

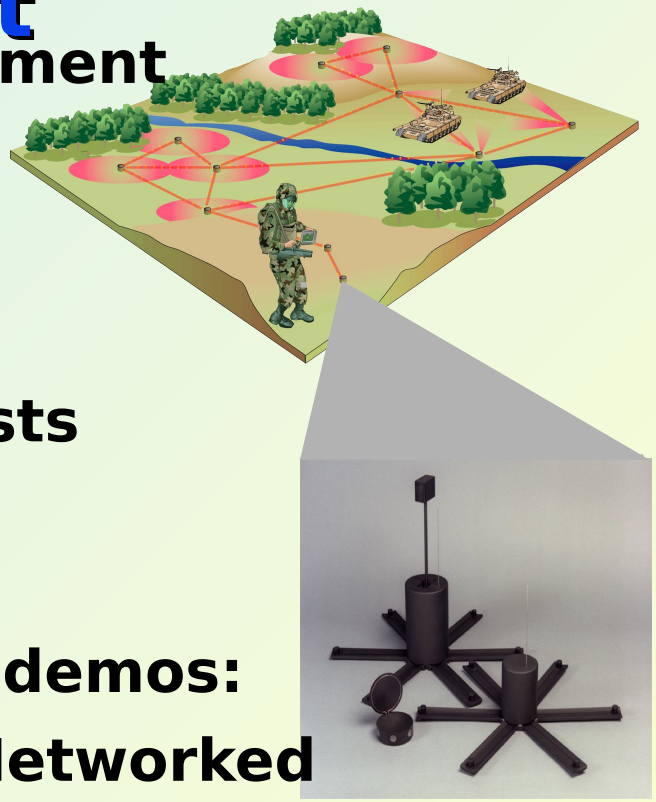




- Joint iterative decoding and authentication
- Compressed intrusion data dissemination
- Intrusion detection for

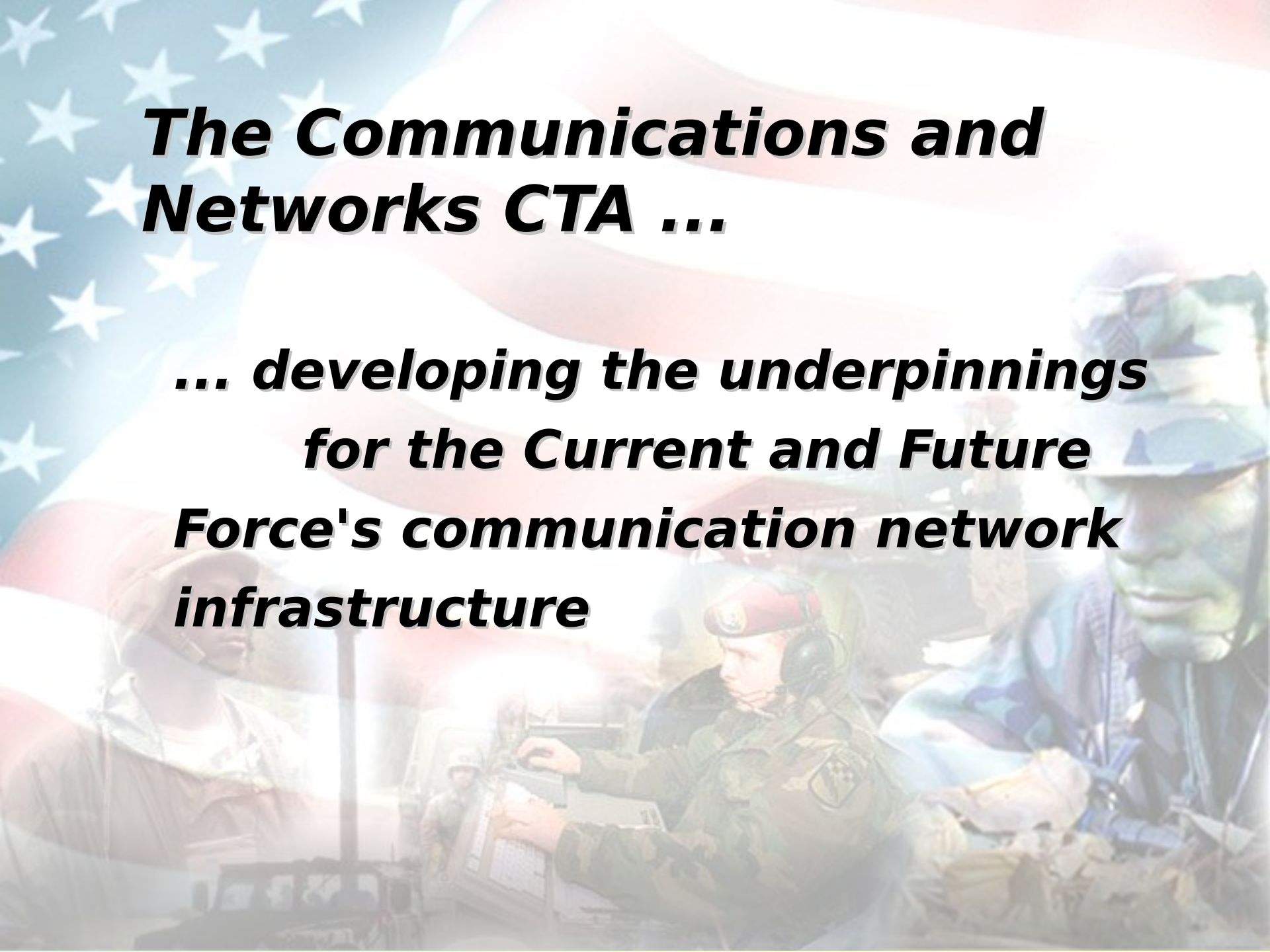
Self-Authenticating and Bandwidth-Efficient Key Management

- **Identity-Based Group Key Management**
  - **Self-authenticating**
  - **Without reliance on certificate authority**
  - **Reduces energy and latency costs by up to 10 times**



- **Energy-efficient key management demos:**
  - **Sensor network comms in the Networked Sensors for the Future Force (NSfFF) ATD**
  - **MOSAIC mobile network security demonstrated in the Tactical Wireless Network Assurace (TWNA) STO**

Transitioned to the CERDEC NSfFF ATD and TWNA STO



The Communications and Networks CTA …

… developing the underpinnings for the Current and Future Force's communication network infrastructure